

PATENT ABSTRACTS OF JAPAN

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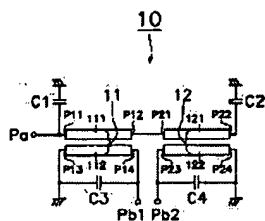
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(21)Application number : 11-346001 (71)Applicant : MURATA MFG CO LTD

(22)Date of filing : 06.12.1999 (72)Inventor : FUJIKAWA KATSUHIKO
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(54) BALANCED-TO-UNBALANCED TRANSFORMER, FREQUENCY
CONVERTER AND MOBILE COMMUNICATION EQUIPMENT



(57)Abstract:

PROBLEM TO BE SOLVED: To provide a balanced-to-unbalanced transformer that is small in size and also inexpensive, a frequency converter and mobile communication equipment.

SOLUTION: This balanced-to-unbalanced transformer 10 is provided with 1st coupled lines 11 having a 1st line 111 of 1/4 wavelength where both ends

become 1st and 2nd terminals P11 and P12 and a 2nd line 112 of $1/4$ wavelength where both ends become 3rd and 4th terminals P13 and P14, 2nd coupled lines 12 having a 1st line 121 of $1/4$ wavelength where both ends become 1st and 2nd terminals P21 and P22 and a 2nd line 122 of $1/4$ wavelength where both ends become 3rd and 4th terminals P23 and P24 and capacitors C1 to C4. Then, the terminal P11 of the lines 11 is connected to an unbalanced signal input- output terminal Pa, and the terminal P14 of the lines 11 and the terminal P23 of the lines 12 are connected to balanced signal input- output terminals Pb1 and Pb2.

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CLAIMS

[Claim(s)]

[Claim 1] The 1st line where ends serve as the 1st and 2nd terminals, and the 1st tie way which has the 2nd line where ends serve as the 3rd and 4th terminals, It has the 2nd tie way which has the 1st line where ends serve as the 1st and 2nd terminals, and the 2nd line where ends serve as the 3rd and 4th terminals. The 2nd terminal of said 1st tie way and the 1st terminal of said 2nd tie way are connected. The 3rd terminal of said 1st tie way and the 4th terminal of said 2nd tie way are grounded, respectively. The 2nd terminal of said 2nd tie way is opened. The 1st terminal of said 1st tie way An unbalance signal input/output terminal, It is the balanced unbalance converter from which the 4th terminal of said 1st tie way and the 3rd terminal of said 2nd tie way turn into a balanced signal input/output terminal. The balanced unbalance converter characterized by connecting a capacitor to at least one between the 3rd terminal of said 1st tie way, and the 4th terminal, and between the 3rd terminal of said 2nd tie way, and the 4th terminal between the 2nd terminal of said 2nd tie way, and a gland between the 1st terminal of said 1st tie way, and a gland.

[Claim 2] The balanced unbalance converter according to claim 1 characterized by said 1st tie way, the 2nd tie way, and a capacitor consisting of layered products which come to carry out the laminating of two or more dielectric layers.

[Claim 3] It is the frequency converter characterized by being a frequency

converter equipped with the distributor which is 180-degree phase contrast and carries out equipartition of the local oscillation signal, the mixer which changes an input signal according to two output signals from this distributor, and the synthetic vessel which compounds two output signals changed with this mixer, and said distributor consisting of a claim 1 or a balanced unbalance converter according to claim 2.

[Claim 4] It is the mobile communication device characterized by being a mobile communication device equipped with at least the sending circuit which has a frequency converter, or a receiving circuit either [an antenna and], and said frequency converter consisting of frequency converters according to claim 3.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the balanced unbalance converter which allots a RF signal 1GHz or more a compounded part, a frequency converter, and a mobile communication device about a balanced unbalance converter, a frequency converter, and a mobile communication device.

[0002]

[Description of the Prior Art] the RF circuit which generally forms a mobile communication device -- setting -- a RF signal -- amplifier and a mixer -- about 180 degrees -- a phase -- shifting -- about 180 degrees from equipartition or amplifier, or a mixer -- a phase -- shifting -- etc. -- it is necessary to compound Therefore, a RF signal is 180-degree ***** carried out, the balanced unbalance converter which carries out distribution composition is arranged to the input side or output side of amplifier, a mixer, etc., and a RF circuit is constituted.

[0003] Drawing 7 is the block diagram showing the circuitry of the portable telephone which is one of the mobile communication devices. A duplexer 51 distributes the electric wave received through the antenna 52 to a receiving-circuit 54 side while sending out the RF signal from a sending circuit 53 to an antenna 52 side. A sending circuit 53 consists of a low pass filter 551,552, a high power amplifier 56, the double balance mixer 57, balanced unbalance converters 581-583, and a local oscillation circuit 59. The intermediate frequency signal and local oscillation signal with which about 180 degrees of phases differ are needed for the intermediate frequency signal input terminals a and b of the double balance mixer 57, and the local oscillation signal input terminals c and d. In this case, since the local oscillation signal supplied from the intermediate frequency signal through a low pass filter 551 or the local oscillation circuit 59 is an unbalance signal as a single end output, the balanced unbalance transducer 582,583 which achieves the duty of the distributor which is 180-degree phase contrast, carries out equipartition of the unbalance signal, and makes it a balanced signal is connected between the double balance mixer 57 and the local oscillation circuit 59 between the double balance mixer 57 and a low pass filter 552, respectively. Moreover, the RF signal changed by the intermediate frequency signal and the local oscillation signal is outputted to the output terminals e and f of the double balance mixer 57 as a balanced signal, and the low pass filter 551 for removing an unnecessary spurious signal is supplied. Here, since a low pass filter 551 is an unbalanced input, the balanced unbalance

transducer 581 which achieves the duty of the synthetic vessel which compounds the balanced signal outputted from the output terminals e and f of the double balance mixer 57, and is made into an unbalance signal is connected between the double balance mixer 57 and a low pass filter 551.

[0004] Drawing 8 is the representative circuit schematic of the conventional balanced unbalance converter. The balanced unbalance transducer 60 is called MACHANDOBARAN which shifts 180 degrees of phases and allots a signal a compounded part, and is reported by R.Schwindt (1994 IEEE MTT-S International Microwave Symposium Digest, pp.389-391).

[0005] The balanced unbalance converter 60 is equipped with the 1st tie way 61 of the die length of the quarter-wave length which has the 1st terminal 611 - the 4th terminal 614, and the 2nd tie way 62 of the die length of the quarter-wave length which has the 1st terminal 621 - the 4th terminal 624. The 2nd terminal 612 of the 1st tie way 61 and the 1st terminal 621 of the 2nd tie way 62 are connected, the 3rd terminal 613 of the 1st tie way 61 and the 4th terminal 624 of the 2nd tie way 62 are grounded, and the 2nd terminal 622 of the 2nd tie way 62 is opened. And an unbalance signal input/output terminal, the 4th terminal 614 of the 1st tie way 61, and the 3rd terminal 623 of the 2nd tie way 62 turn into [the 1st terminal 611 of the 1st tie way 61] a balanced signal input/output terminal.

[0006] Drawing 9 is the mimetic diagram of a voltage-current wave of the standing wave on the 1/2-wave line in the balanced unbalance converter of drawing 8 . With the 2nd terminal 612 of the 1st tie way 61 in the location of quarter-wave length, and the 1st terminal 621 of the 2nd tie way 62, Current I serves as max and an electrical potential difference V is set to 0. Moreover, an electrical potential difference V serves as an opposite phase with an equal amplitude before and behind the 2nd terminal 612 of the 1st tie way 61, and the 1st terminal 621 of the 2nd tie way 62.

[0007] In addition, there is JP,11-144961,A as an example which constituted the balanced unbalance converter equipped with an equal circuit like drawing 8 from a laminated structure. The surface mount mold balance unbalance converter of

the structure which carried out the laminating of the 1st tie way and the 2nd tie way to the lengthwise direction of the dielectric substrate which consists of crystallized glass etc. is indicated by this.

[0008]

[Problem(s) to be Solved by the Invention] However, in the above-mentioned conventional portable telephone, since the low pass filter and the balanced unbalance transducer were constituted as separate discrete part, cost started manufacture and attachment and it had been set to one of the causes which obstruct the miniaturization of a portable telephone. Moreover, transmission loss was generated between the low pass filter and the balanced unbalance converter, and the power consumption of a portable telephone was increased.

[0009] This invention is made in order to solve such a trouble, and it aims at offering a small and cheap balanced unbalance converter, a frequency converter, and a mobile communication device.

[0010]

[Means for Solving the Problem] In order to solve the trouble mentioned above the balanced unbalance converter of this invention The 1st line where ends serve as the 1st and 2nd terminals, and the 1st tie way which has the 2nd line where ends serve as the 3rd and 4th terminals, It has the 2nd tie way which has the 1st line where ends serve as the 1st and 2nd terminals, and the 2nd line where ends serve as the 3rd and 4th terminals. The 2nd terminal of said 1st tie way and the 1st terminal of said 2nd tie way are connected. The 3rd terminal of said 1st tie way and the 4th terminal of said 2nd tie way are grounded, respectively. The 2nd terminal of said 2nd tie way is opened. The 1st terminal of said 1st tie way An unbalance signal input/output terminal, It is the balanced unbalance converter from which the 3rd terminal of the 4th edge of said 1st tie way and said 2nd tie way turns into a balanced signal input/output terminal. It is characterized by connecting a capacitor to at least one between the 3rd terminal of said 1st tie way, and the 4th terminal, and between the 3rd terminal of said 2nd tie way, and the 4th terminal between the 2nd terminal of said 2nd tie way, and a gland

between the 1st terminal of said 1st tie way, and a gland.

[0011] Moreover, the balanced unbalance transducer of this invention is characterized by said 1st tie way, the 2nd tie way, and a capacitor consisting of layered products which come to carry out the laminating of two or more dielectric layers.

[0012] The frequency converter of this invention is a frequency converter equipped with the distributor which is 180-degree phase contrast and carries out equipartition of the local oscillation signal, the mixer which changes an input signal according to two output signals from this distributor, and the synthetic vessel which compounds two output signals changed with this mixer, and said distributor is characterized by consisting of above-mentioned balanced unbalance converters.

[0013] The mobile communication device of this invention is a mobile communication device equipped with either [an antenna and / at least] the sending circuit which has a frequency converter, or a receiving circuit, and said frequency converter is characterized by consisting of above-mentioned frequency converters.

[0014] Between the 1st terminal of the 1st tie way, and a gland, between the 2nd terminal of the 2nd tie way, and a gland, since a capacitor is connected to at least one between the 3rd terminal of the 1st tie way, and the 4th terminal, and between the 3rd terminal of the 2nd tie way, and the 4th terminal, according to the balanced unbalance converter of this invention, the balanced unbalance converter which has low-pass-filter ability can be constituted.

[0015] Since the balanced unbalance converter which has low-pass-filter ability is used according to the frequency converter of this invention, components mark can be lessened.

[0016] According to the mobile communication device of this invention, since the frequency converter in which low-cost-izing, a miniaturization, and high-performance-izing are possible is used, low-cost-izing of a mobile communication device, a miniaturization, and high performance-ization are realizable.

[0017]

[Embodiment of the Invention] Hereafter, the example of this invention is explained with reference to a drawing. Drawing 1 is the representative circuit schematic of one example concerning the balanced unbalance converter of this invention. The 1st tie way 11 where the balanced unbalance converter 10 has the 1st line 111 of the die length of quarter-wave length where ends serve as the 1st and 2nd terminals P11 and P12, and the 2nd line 112 of the die length of quarter-wave length where ends serve as the 3rd and 4th terminals P13 and P14, It has the 2nd tie way 12 which has the 1st line 121 of the die length of quarter-wave length where ends serve as the 1st and 2nd terminals P21 and P22, and the 2nd line 122 of the die length of quarter-wave length where ends serve as the 3rd and 4th terminals P23 and P24, and capacitors C1-C4.

[0018] The 2nd terminal P12 of the 1st tie way 11 and the 1st terminal P21 of the 2nd tie way 12 are connected, the 3rd terminal P13 of the 1st tie way 11 and the 4th terminal P24 of the 2nd tie way 12 are grounded, and the 2nd terminal P22 of the 2nd tie way 12 is opened.

[0019] Moreover, a capacitor C4 is connected between the 1st terminal P11 of the 1st tie way 11, and a gland between the 2nd terminal P22 of a capacitor C1 and the 2nd tie way 12, and a gland, and is connected [between the 3rd terminal P13 of a capacitor C2 and the 1st tie way 11, and the 4th terminal P14], respectively between the 3rd terminal P23 of a capacitor C3 and the 2nd tie way 12, and the 4th terminal P24.

[0020] And the unbalance signal input/output terminal Pa, the 4th terminal P14 of the 1st tie way 11, and the 3rd terminal P23 of the 2nd tie way 12 are connected to the balanced signal input/output terminals Pb1 and Pb2 for the 1st terminal P11 of the 1st tie way 11.

[0021] Drawing 2 is the perspective view of the balanced unbalance converter of drawing 1 . The balanced unbalance converter 10 is equipped with the layered product 13 which built in the transmission line which constitutes the 1st tie way 11 and the 2nd tie way 12 and the grand electrode (not shown), the capacitor

electrode which constitutes capacitors C1-C4, and the grand electrode (not shown). It applies to an underside from the top face of a layered product 13, and the external terminals T1-T6 are formed.

[0022] In addition, as for the external terminals T1 and T6, a balanced signal input/output terminal and the external terminal T2 turn into an unbalance signal input/output terminal, and external terminal T3-T5 turn into a grand terminal.

[0023] Drawing 3 (a) - drawing 3 (h) and drawing 4 (a) - drawing 4 (e) are the plans or bottom views of each dielectric layer which constitute the layered product of the balanced unbalance converter of drawing 2 . A layered product 13 is formed by carrying out the laminating of the 1st - the 12th dielectric layer 13a-13l. which consist of a low-temperature baking ceramic which uses as a principal component the barium oxide which can be calcinated at the temperature of 850 degrees C - 1000 degrees C, an aluminum oxide, and a silica one by one.

[0024] The external terminals T1-T6 are formed in the top face of 1st dielectric layer 13a. Moreover, the grand electrodes Gp1-Gp3 are formed in a dielectric layers [2nd, 7th, and 12th /b / 13 /,g / 13 /, and 13l.] top face, respectively.

[0025] Furthermore, the capacitor electrodes Cp1-Cp4 are formed in the top face of the 3rd, 6th, 8th, and 11th dielectric layers 13c, 13f, 13h, and 13k, respectively. Moreover, the transmission lines Sp1-Sp4 are formed in the top face of the 4th, 5th, 9th, and 10th dielectric layers 13d, 13e, 13i, and 13j, respectively.

[0026] Furthermore, the external terminals T1-T6 are formed in the underside (lu and a sign are attached in drawing 4 (e)) of the 13l. of the 12th dielectric layer. Furthermore, the beer hall electrode Vh is formed in the 3rd - the 8th, 10th, and 11th dielectric layers 13c-13h, and 13j and 13k so that each dielectric layers 13c-13h, and 13j and 13k may be penetrated.

[0027] Under the present circumstances, the 1st and 2nd lines 111,112 (drawing 1) of the 1st tie way 11 are consisted of from the transmission lines Sp1 and Sp2, and the 1st and 2nd lines 121,122 (drawing 1) of the 2nd tie way 12 consist of the transmission lines Sp3 and Sp4, respectively. Moreover, capacitors C1-C4 (drawing 1) consist of the capacitor electrode Cp1, the grand electrode Gp1 and

the capacitor electrode Cp3, the grand electrode Gp2 and the capacitor electrode Cp2, the grand electrode Gp2 and the capacitor electrode Cp4, and a grand electrode Gp3, respectively.

[0028] The balanced unbalance converter 10 equipped with the layered product 13 which builds in the 1st tie way 11 (drawing 1), the 2nd tie way 12 (drawing 1), and capacitors C1-C4 (drawing 1) with the above configurations is formed.

[0029] Drawing 5 is (a) phase characteristic drawing showing basic actuation of the balanced unbalance converter of drawing 1 , and (b) passage property drawing. In drawing 5 , a continuous line shows between the 4th terminal (balanced signal input/output terminal) P14 of the 1st terminal (unbalance signal input/output terminal) P11-1st tie way 11 of the 1st tie way 11, and a broken line shows between the 3rd terminal (balanced signal input/output terminal) P23 of the 1st terminal (unbalance signal input/output terminal) P11-2nd tie way 12 of the 1st tie way 11.

[0030] Drawing 5 (a) shows that 180 degrees of phases are reversed between the 3rd terminal P23 of the 1st terminal P11-2nd tie way 12 of the 1st tie way 11 between the 4th terminal P14 of the 1st terminal P11-1st tie way 11 of the 1st tie way 11 in the balanced unbalance converter 10 of drawing 2 .

[0031] Moreover, pi mold low pass filter which consists of drawing 5 (b) by the 1st line 121 and capacitors C1 and C2 of the 1st line 111 of the 1st tie way 11, and the 2nd tie way 12, With the parallel resonance mold low pass filter constituted from the 2nd line 122 of the 2nd tie way 12, and a capacitor C4 by the parallel resonance mold low pass filter which consists of the 2nd line 112 of the 1st tie way 11, and a capacitor C3, and the list It turns out that secondary 3 order higher-harmonic $2f_0$ of clock frequency f_0 and $3f_0$ can fully be decreased.

[0032] Between the 1st terminal of the 1st tie way, and a gland, between the 2nd terminal of the 2nd tie way, and a gland, since a capacitor is connected between the 3rd terminal of the 1st tie way, and the 4th terminal, and between the 3rd terminal of the 2nd tie way, and the 4th terminal, according to the balanced unbalance converter of the example mentioned above, the balanced unbalance

converter which has low-pass-filter ability can be constituted. Therefore, the balanced unbalance converter which can attain the balanced unbalance converter which has low-pass-filter ability with easy structure as compared with the conventional example which forms a balanced unbalance converter and a low pass filter as separate components, consequently has low-cost-izing and the low-pass-filter ability which was miniaturized and, in addition, realized reduction of the transmission loss between balanced unbalance converter-low pass filters can be obtained.

[0033] Moreover, since it constitutes from the transmission line which established the 1st and 2nd tie way in the interior of a layered product and constitutes from the capacitor electrode and grand electrode which countered the interior of a layered product mutually and formed the capacitor in it on both sides of the dielectric layer while having the layered product which comes to carry out the laminating of the 1st - the 12th dielectric layer, the components mark of a balanced unbalance converter can be reduced. Therefore, low-cost-izing and a miniaturization are more possible than that of a balanced unbalance converter.

[0034] Drawing 6 is the block diagram of one example concerning the mobile communication device of this invention. The mobile communication device 20 consists of an antenna 21, a duplexer 22, a sending circuit 23, and a receiving circuit 24.

[0035] A duplexer 22 distributes the electric wave received through the antenna 21 to a receiving-circuit 24 side while sending out the RF signal from a sending circuit 23 to an antenna 21 side.

[0036] A sending circuit 23 consists of a high power amplifier PA, a frequency converter CON1, and the modulation section MOD, and a receiving circuit 24 consists of a low noise amplifier LNA, a frequency converter CON2, and the recovery section DEM.

[0037] Under the present circumstances, the frequency converter CON1 of a sending circuit 23 consists of the balanced unbalance transducers BAL11, BAL12, and BAL3, a double balance mixer MIX1, and a local oscillation circuit

LO, and the frequency converter CON2 of a receiving circuit 24 consists of the balanced unbalance transducers BAL21, BAL22, and BAL3, a double balance mixer MIX2, and a local oscillation circuit LO.

[0038] In addition, the balanced unbalance converters BAL11 and BAL22 achieve the duty of the distributor which is 180-degree phase contrast, carries out equipartition of the unbalance signal, and makes it a balanced signal, and the balanced unbalance converters BAL12 and BAL21 achieve the duty of the synthetic vessel which compounds a balanced signal and is made into an unbalance signal.

[0039] In the above configurations, the balanced unbalance converter 10 which has the low-pass-filter ability of drawing 1 is used for the balanced unbalance converters BAL11, BAL21, BAL12, and BAL22 which constitute frequency converters CON1 and CON2.

[0040] In the case of transmission, a local oscillation signal is supplied for an intermediate frequency signal to the intermediate frequency signal input terminals a1 and b1 of the double balance mixer MIX1 in a sending circuit 23 through the balanced unbalance converter BAL 3 at the local oscillation signal input terminals c1 and d1 through the balanced unbalance converter BAL 12, respectively, and the RF signal changed from output terminals e1 and f1 by the intermediate frequency signal and the local oscillation signal is outputted.

[0041] On the other hand, in the case of reception, a local oscillation signal is supplied for a RF signal to the RF signal input terminals a2 and b2 of the double balance mixer MIX2 in a receiving circuit 24 through the balanced unbalance converter BAL 3 at the local oscillation signal input terminals c2 and d2 through the balanced unbalance converter BAL 21, respectively, and the intermediate frequency signal changed from output terminals e2 and f2 by the RF signal and the local oscillation signal is outputted.

[0042] In addition, the unnecessary spurious signal in a RF signal and an intermediate frequency signal is removed by the low-pass-filter ability which the balanced unbalance converters BAL11, BAL12, BAL21, and BAL22 have.

[0043] Since the balanced unbalance converter which has low-pass-filter ability is used according to the frequency converter of the example mentioned above, while being able to lessen components mark, transmission loss can be reduced, consequently low-cost-izing of a frequency converter, miniaturization, and high performance-ization can be realized.

[0044] Moreover, according to the mobile communication device of the example mentioned above, since the frequency converter in which low-cost-izing, a miniaturization, and high-performance-izing are possible is used, low-cost-izing of a mobile communication device, a miniaturization, and high performance-ization are realizable.

[0045] In addition, although the example of an above-mentioned balanced unbalance converter explained the case where a capacitor was connected to all between the 3rd terminal of the 1st tie way, and the 4th terminal, and between the 3rd terminal of the 2nd tie way, and the 4th terminal between the 2nd terminal of the 2nd tie way, and a gland between the 1st terminal of the 1st tie way, and a gland If a capacitor is connected to at least one place, it will have the function of a low pass filter and the same effectiveness will be acquired.

[0046] Moreover, although the dielectric layer explained the case of the ceramics which uses the barium oxide, an aluminum oxide, and a silica as a principal component, effectiveness with the same said also of the ceramics or fluororesin which which ingredient is sufficient as with [specific inductive capacity (ϵ_r)] one [or more], for example, uses a magnesium oxide and a silica as a principal component is acquired.

[0047] Furthermore, although the above-mentioned mobile communication device explained the case where a balanced unbalance converter and a local oscillation circuit were carried out in common with the frequency converter of a sending circuit, and the frequency converter of a receiving circuit, it may be prepared independently.

[0048]

[Effect of the Invention] According to the balanced unbalance converter of claim 1,

between the 1st terminal of the 1st tie way, and a gland, In order to connect a capacitor to at least one between the 3rd terminal of the 1st tie way, and the 4th terminal, and between the 3rd terminal of the 2nd tie way, and the 4th terminal between the 2nd terminal of the 2nd tie way, and a gland, It compares with the conventional example which forms a balanced unbalance converter and a low pass filter as separate components. The balanced unbalance converter which can attain the balanced unbalance converter which has low-pass-filter ability with easy structure, consequently has low-cost-izing and the low-pass-filter ability which was miniaturized and, in addition, realized reduction of the transmission loss between balanced unbalance converter-low pass filters can be obtained.

[0049] Since the 1st tie way, the 2nd tie way, and a capacitor consist of layered products which come to carry out the laminating of two or more dielectric layers according to the balanced unbalance transducer of claim 2, the components mark of a balanced unbalance transducer can be reduced. Therefore, low-cost-izing and a miniaturization are more possible than that of a balanced unbalance converter.

[0050] Since the balanced unbalance converter which has low-pass-filter ability is used according to the frequency converter of claim 3, while being able to lessen components mark, transmission loss can be reduced, consequently low-cost-izing of a frequency converter, miniaturization, and high performance-ization can be realized.

[0051] According to the mobile communication device of claim 4, since the frequency converter in which low-cost-izing, a miniaturization, and high-performance-izing are possible is used, low-cost-izing of a mobile communication device, a miniaturization, and high performance-ization are realizable.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the representative circuit schematic of one example concerning the balanced unbalance converter of this invention.

[Drawing 2] It is the perspective view showing an example unbalance converter [of drawing 1 / balanced] configuration.

[Drawing 3] It is the plan of the (a) 1st dielectric layer - (h) 8th dielectric layer which constitutes the layered product of the balanced unbalance converter of drawing 2 .

[Drawing 4] They are the plan of the (a) 9th dielectric layer - (d) 12th dielectric layer which constitutes the layered product of the balanced unbalance converter of drawing 2 , and the bottom view of the (e) 12th dielectric layer.

[Drawing 5] They are (a) phase characteristic drawing showing basic actuation of the balanced unbalance converter of drawing 1 , and (b) passage property drawing.

[Drawing 6] It is the block diagram of one example concerning the mobile communication device of this invention.

[Drawing 7] It is the block diagram showing the circuitry of a common portable telephone.

[Drawing 8] It is the representative circuit schematic of the conventional balanced unbalance converter.

[Drawing 9] It is the mimetic diagram of a voltage-current wave of the standing

wave on the 1/2-wave line in a ***** unbalance converter.

[Description of Notations]

10 Balanced Unbalance Converter

11 1st Tie Way

12 2nd Tie Way

111,121 The 1st line

112,122 The 2nd line

13 Layered Product

13a-13l. Dielectric layer

20 Mobile Communication Device

21 Antenna

23 Sending Circuit

24 Receiving Circuit

C1-C4 Capacitor

CON1, CON2 Frequency converter

DEM Recovery section

MOD Modulation section

P11-P14, P21-P24 The 1st - the 4th terminal

Pa Balanced signal input/output terminal

Pb1, Pb2 Unbalance signal input/output terminal

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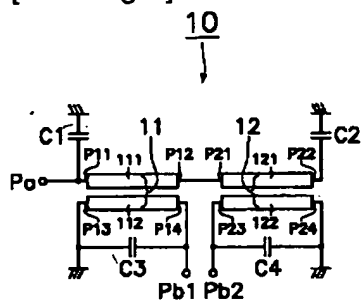
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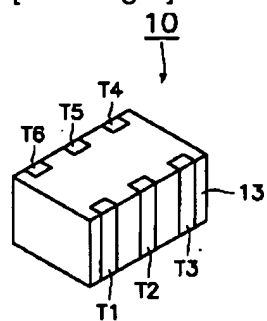
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DRAWINGS

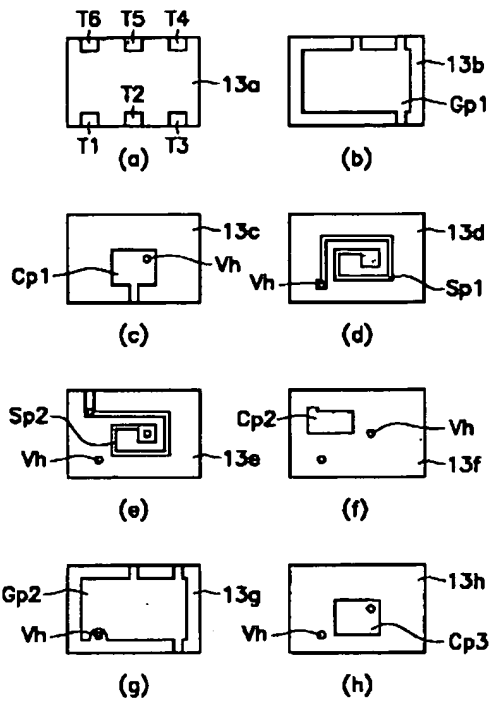
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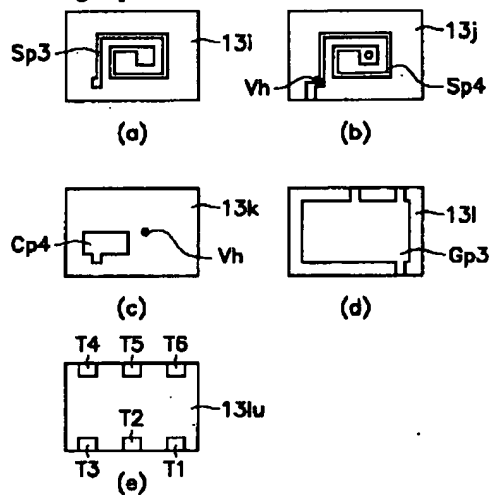
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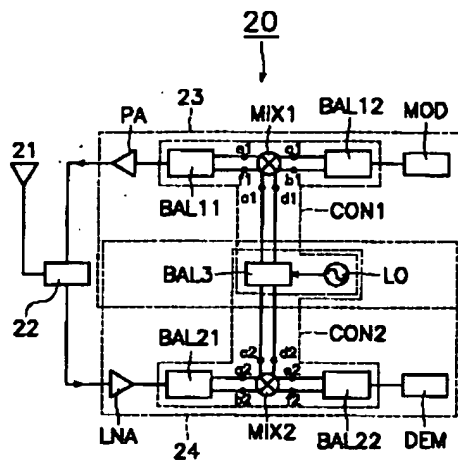
[Drawing 3]



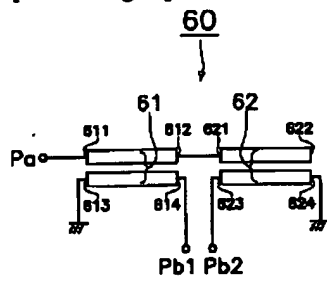
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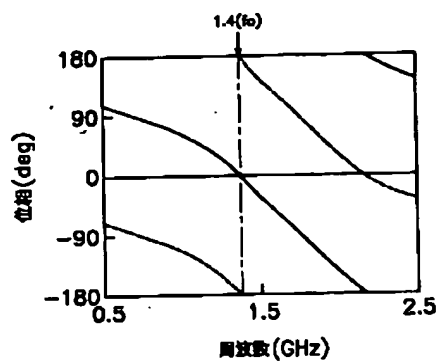
[Drawing 6]



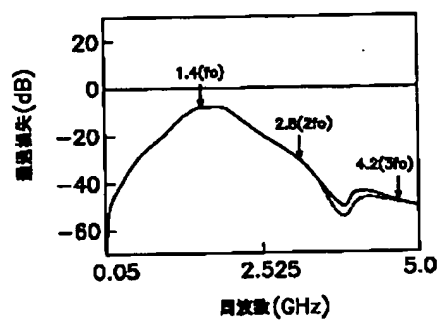
[Drawing 8]



[Drawing 5]

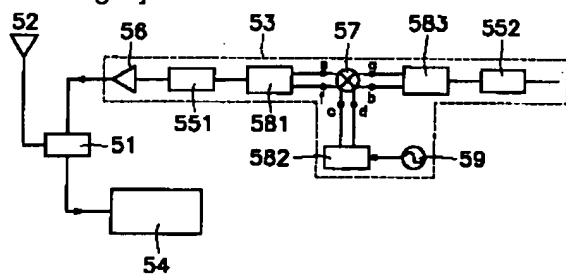


(a)

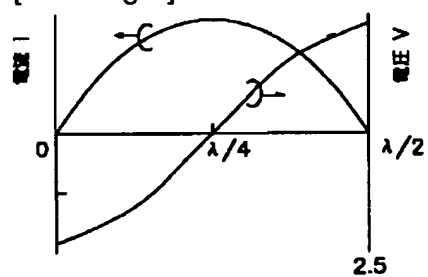


(b)

[Drawing 7]



[Drawing 9]



[Translation done.]

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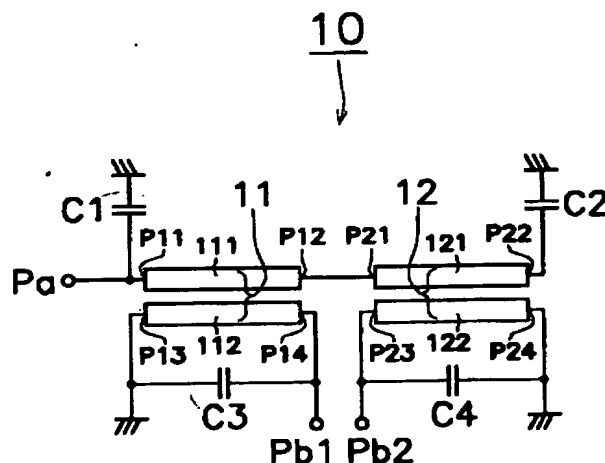
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(54) 【発明の名称】 平衡不平衡変換器、周波数変換器、及び移動体通信装置

(57) 【要約】

【課題】 小型でかつ安価な平衡不平衡変換器、周波数変換器、及び移動体通信装置を提供する。

【解決手段】 平衡不平衡変換器 10 は、両端が第 1 及び第 2 端子 P 1 1, P 1 2 となる 1/4 波長の長さの第 1 線路 1 1 1、及び両端が第 3 及び第 4 端子 P 1 3, P 1 4 となる 1/4 波長の長さの第 2 線路 1 1 2 を有する第 1 結合線路 1 1 と、両端が第 1 及び第 2 端子 P 2 1, P 2 2 となる 1/4 波長の長さの第 1 線路 1 2 1、及び両端が第 3 及び第 4 端子 P 2 3, P 2 4 となる 1/4 波長の長さの第 2 線路 1 2 2 を有する第 2 結合線路 1 2 と、コンデンサ C 1 ~ C 4 とを備える。そして、第 1 結合線路 1 1 の第 1 端子 P 1 1 が不平衡信号入出力端子 P a、第 1 結合線路 1 1 の第 4 端子 P 1 4 及び第 2 結合線路 1 2 の第 3 端子 P 2 3 が平衡信号入出力端子 P b 1, P b 2 に接続される。



【特許請求の範囲】

【請求項1】 両端が第1及び第2端子となる第1線路、及び両端が第3及び第4端子となる第2線路を有する第1結合線路と、両端が第1及び第2端子となる第1線路、及び両端が第3及び第4端子となる第2線路を有する第2結合線路とを備え、前記第1結合線路の第2端子と前記第2結合線路の第1端子とが接続され、前記第1結合線路の第3端子と前記第2結合線路の第4端子とがそれぞれ接地され、前記第2結合線路の第2端子が開放され、前記第1結合線路の第1端子が不平衡信号入出力端子、前記第1結合線路の第4端子及び前記第2結合線路の第3端子が平衡信号入出力端子となる平衡不平衡変換器であって、

前記第1結合線路の第1端子、グランド間、前記第2結合線路の第2端子、グランド間、前記第1結合線路の第3端子、第4端子間、及び前記第2結合線路の第3端子、第4端子間の少なくとも1つにコンデンサを接続したことを特徴とする平衡不平衡変換器。

【請求項2】 前記第1結合線路、第2結合線路及びコンデンサが、複数の誘電体層を積層してなる積層体で構成されることを特徴とする請求項1に記載の平衡不平衡変換器。

【請求項3】 局部発振信号を 180° の位相差で等分配する分配器と、該分配器からの2つの出力信号に応じて入力信号を変換するミキサと、該ミキサで変換された2つの出力信号を合成する合成器とを備える周波数変換器であって、前記分配器は、請求項1あるいは請求項2に記載の平衡不平衡変換器で構成されることを特徴とする周波数変換器。

【請求項4】 アンテナと、周波数変換器を有する送信回路及び受信回路の少なくとも一方とを備える移動体通信装置であって、前記周波数変換器は、請求項3に記載の周波数変換器で構成されることを特徴とする移動体通信装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、平衡不平衡変換器、周波数変換器、及び移動体通信装置に関し、特に、1GHz以上の高周波信号を合成分配する平衡不平衡変換器、周波数変換器、及び移動体通信装置に関する。

【0002】

【従来の技術】一般に、移動体通信装置を形成する高周波回路において、高周波信号を増幅器やミキサに 180° 位相をずらして等分配、または増幅器やミキサから 180° 位相をずらして等合成する必要がある。そのために、高周波信号を 180° 位相ずらして分配合成する平衡不平衡変換器を増幅器やミキサなどの入力側または出力側に配置し、高周波回路を構成する。

【0003】図7は、移動体通信装置の1つである携帯電話機の回路構成を示すブロック図である。デュプレク

サ51は、送信回路53からの高周波信号をアンテナ52側へ送出するとともに、アンテナ52を介して受信した電波を受信回路54側へ振り分ける。送信回路53は、低域通過フィルタ551、552、高出力増幅器56、ダブルバランスミキサ57、平衡不平衡変換器581～583及び局部発振回路59からなる。ダブルバランスミキサ57の中間周波信号入力端子a、b、局部発振信号入力端子c、dには、 180° 位相の異なる中間周波信号や局部発振信号が必要とされる。この場合、低域通過フィルタ551を介した中間周波信号や局部発振回路59から供給される局部発振信号はシングルエンド出力としての不平衡信号であるため、不平衡信号を 180° の位相差で等分配して平衡信号とする分配器の役目を果たす平衡不平衡変換器582、583が、ダブルバランスミキサ57と低域通過フィルタ552との間、ダブルバランスミキサ57と局部発振回路59との間にそれぞれ接続される。また、ダブルバランスミキサ57の出力端子e、fには中間周波信号と局部発振信号とにより変換された高周波信号が平衡信号として出力され、不要なスプリアス信号を除去するための低域通過フィルタ551に供給される。ここで、低域通過フィルタ551は不平衡入力であるため、ダブルバランスミキサ57の出力端子e、fから出力される平衡信号を合成して不平衡信号とする合成器の役目を果たす平衡不平衡変換器581が、ダブルバランスミキサ57と低域通過フィルタ551との間に接続される。

【0004】図8は、従来の平衡不平衡変換器の等価回路図である。平衡不平衡変換器60は、位相を 180° ずらして信号を合成分配するマーチャンドバランと呼ばれるもので、R. Schwindtにより報告されている(1994 IEEE MTT-S International Microwave Symposium Digest, pp. 389-391)。

【0005】平衡不平衡変換器60は、第1端子611～第4端子614を有する $1/4$ 波長の長さの第1結合線路61と、第1端子621～第4端子624を有する $1/4$ 波長の長さの第2結合線路62とを備える。第1結合線路61の第2端子612と第2結合線路62の第1端子621とが接続され、第1結合線路61の第3端子613、及び第2結合線路62の第4端子624が接地され、第2結合線路62の第2端子622が開放される。そして、第1結合線路61の第1端子611が不平衡信号入出力端子、第1結合線路61の第4端子614及び第2結合線路62の第3端子623が平衡信号入出力端子となる。

【0006】図9は、図8の平衡不平衡変換器における $1/2$ 波長線路上の定在波の電圧・電流波形の模式図である。 $1/4$ 波長の位置にある第1結合線路61の第2端子612及び第2結合線路62の第1端子621で、電流Iは最大となり、電圧Vは0となる。また、電圧Vは第1結合線路61の第2端子612及び第2結合線路

62の第1端子621の前後では等振幅で逆位相となる。

【0007】なお、図8のような等価回路を備えた平衡不平衡変換器を積層構造で構成した例として、特開平11-144961号公報がある。これには、第1結合線路と第2の結合線路をガラスセラムックス等からなる誘電体基板の縦方向に積層した構造の表面実装型平衡不平衡変換器が開示されている。

【0008】

【発明が解決しようとする課題】ところが、上記従来の携帯電話機においては、低域通過フィルタと平衡不平衡変換器とを別々のディスクリート部品として構成しているため、製造及び組み付けにコストがかかり、携帯電話機の小型化を阻む原因の1つとなっていた。また、低域通過フィルタと平衡不平衡変換器との間で伝送損失を発生させ、携帯電話機の消費電力を増大させていた。

【0009】本発明は、このような問題点を解決するためになされたものであり、小型でかつ安価な平衡不平衡変換器、周波数変換器、及び移動体通信装置を提供することを目的とする。

【0010】

【課題を解決するための手段】上述する問題点を解決するため本発明の平衡不平衡変換器は、両端が第1及び第2端子となる第1線路、及び両端が第3及び第4端子となる第2線路を有する第1結合線路と、両端が第1及び第2端子となる第1線路、及び両端が第3及び第4端子となる第2線路を有する第2結合線路とを備え、前記第1結合線路の第2端子と前記第2結合線路の第1端子とが接続され、前記第1結合線路の第3端子と前記第2結合線路の第4端子とがそれぞれ接地され、前記第2結合線路の第2端子が開放され、前記第1結合線路の第1端子が不平衡信号入出力端子、前記第1結合線路の第4端及び前記第2結合線路の第3端子が平衡信号入出力端子となる平衡不平衡変換器であって、前記第1結合線路の第1端子、グランド間、前記第2結合線路の第2端子、グランド間、前記第1結合線路の第3端子、第4端子間、及び前記第2結合線路の第3端子、第4端子間の少なくとも1つにコンデンサを接続したことを特徴とする。

【0011】また、本発明の平衡不平衡変換器は、前記第1結合線路、第2結合線路及びコンデンサが、複数の誘電体層を積層してなる積層体で構成されることを特徴とする。

【0012】本発明の周波数変換器は、局部発振信号を180°の位相差で等分配する分配器と、該分配器からの2つの出力信号に応じて入力信号を変換するミキサと、該ミキサで変換された2つの出力信号を合成する合成器とを備える周波数変換器であって、前記分配器は、上述の平衡不平衡変換器で構成されることを特徴とする。

【0013】本発明の移動体通信装置は、アンテナと、周波数変換器を有する送信回路及び受信回路の少なくとも一方とを備える移動体通信装置であって、前記周波数変換器は、上述の周波数変換器で構成されることを特徴とする。

【0014】本発明の平衡不平衡変換器によれば、第1結合線路の第1端子、グランド間、第2結合線路の第2端子、グランド間、第1結合線路の第3端子、第4端子間、及び第2結合線路の第3端子、第4端子間の少なくとも1つにコンデンサを接続するため、低域通過フィルタ機能を有する平衡不平衡変換器を構成することができる。

【0015】本発明の周波数変換器によれば、低域通過フィルタ機能を有する平衡不平衡変換器を用いているため、部品点数を少なくすることができる。

【0016】本発明の移動体通信装置によれば、低コスト化、小型化及び高性能化が可能な周波数変換器を用いているため、移動体通信装置の低コスト化、小型化及び高性能化を実現することができる。

【0017】

【発明の実施の形態】以下、図面を参照して本発明の実施例を説明する。図1は、本発明の平衡不平衡変換器に係る一実施例の等価回路図である。平衡不平衡変換器10は、両端が第1及び第2端子P11、P12となる1/4波長の長さの第1線路111、及び両端が第3及び第4端子P13、P14となる1/4波長の長さの第2線路112を有する第1結合線路11と、両端が第1及び第2端子P21、P22となる1/4波長の長さの第1線路121、及び両端が第3及び第4端子P23、P24となる1/4波長の長さの第2線路122を有する第2結合線路12と、コンデンサC1～C4とを備える。

【0018】第1結合線路11の第2端子P12と第2結合線路12の第1端子P21とが接続され、第1結合線路11の第3端子P13、及び第2結合線路12の第4端子P24が接地され、第2結合線路12の第2端子P22が開放される。

【0019】また、第1結合線路11の第1端子P11、グランド間にコンデンサC1、第2結合線路12の第2端子P22、グランド間にコンデンサC2、第1結合線路11の第3端子P13、第4端子P14間にコンデンサC3、第2結合線路12の第3端子P23、第4端子P24間にコンデンサC4がそれぞれ接続される。

【0020】そして、第1結合線路11の第1端子P11が不平衡信号入出力端子Pa、第1結合線路11の第4端子P14及び第2結合線路12の第3端子P23が平衡信号入出力端子Pb1、Pb2に接続される。

【0021】図2は、図1の平衡不平衡変換器の斜視図である。平衡不平衡変換器10は、第1結合線路11及び第2結合線路12を構成する伝送線路及びグランド電

極（図示せず）、コンデンサC1～C4を構成するコンデンサ電極及びグラウンド電極（図示せず）を内蔵した積層体13を備える。積層体13の上面から下面にかけて外部端子T1～T6が設けられる。

【0022】なお、外部端子T1、T6は平衡信号入出力端子、外部端子T2は不平衡信号入出力端子、外部端子T3～T5はグラウンド端子となる。

【0023】図3(a)～図3(h)及び図4(a)～図4(e)は、図2の平衡不平衡変換器の積層体を構成する各誘電体層の上面図あるいは下面図である。積層体13は、例えば850℃～1000℃の温度で焼成可能な酸化バリウム、酸化アルミニウム、シリカを主成分とする低温焼成セラミックからなる第1～第12の誘電体層13a～13lを順次積層することによって形成される。

【0024】第1の誘電体層13aの上面には外部端子T1～T6が形成される。また、第2、第7及び第12の誘電体層13b、13g、13lの上面にはグラウンド電極Gp1～Gp3がそれぞれ形成される。

【0025】さらに、第3、第6、第8及び第11の誘電体層13c、13f、13h、13kの上面にはコンデンサ電極Cp1～Cp4がそれぞれ形成される。また、第4、第5、第9及び第10の誘電体層13d、13e、13i、13jの上面には伝送線路Sp1～Sp4がそれぞれ形成される。

【0026】さらに、第12の誘電体層13lの下面（図4(e)中において、luと符号を付す）には外部端子T1～T6が形成される。さらに、第3～第8、第10及び第11の誘電体層13c～13h、13j、13kには各誘電体層13c～13h、13j、13kを貫通するようにビアホール電極Vhが形成される。

【0027】この際、伝送線路Sp1、Sp2で第1結合線路11の第1及び第2線路111、112（図1）を、伝送線路Sp3、Sp4で第2結合線路12の第1及び第2線路121、122（図1）をそれぞれ構成する。また、コンデンサ電極Cp1とグラウンド電極Gp1、コンデンサ電極Cp3とグラウンド電極Gp2、コンデンサ電極Cp2とグラウンド電極Gp2、コンデンサ電極Cp4とグラウンド電極Gp3とでコンデンサC1～C4（図1）をそれぞれ構成する。

【0028】以上のような構成で、第1結合線路11（図1）、第2結合線路12（図1）、コンデンサC1～C4（図1）を内蔵する積層体13を備えた平衡不平衡変換器10が形成される。

【0029】図5は、図1の平衡不平衡変換器の基本動作を示す(a)位相特性図、(b)通過特性図である。図5において、実線は第1結合線路11の第1端子（不平衡信号入出力端子）P11ー第1結合線路11の第4端子（平衡信号入出力端子）P14間、破線は第1結合線路11の第1端子（不平衡信号入出力端子）P11ー

第2結合線路12の第3端子（平衡信号入出力端子）P23間を示す。

【0030】図5(a)から、図2の平衡不平衡変換器10において、第1結合線路11の第1端子P11ー第1結合線路11の第4端子P14間と第1結合線路11の第1端子P11ー第2結合線路12の第3端子P23間とで位相が180°反転していることが解る。

【0031】また、図5(b)から、第1結合線路11の第1線路111、第2結合線路12の第1線路121及びコンデンサC1、C2で構成されるπ型低域通過フィルタ、第1結合線路11の第2線路112、コンデンサC3で構成される並列共振型低域通過フィルタ、並びに、第2結合線路12の第2線路122、コンデンサC4で構成される並列共振型低域通過フィルタにより、動作周波数foの2次及び3次高調波2fo、3foを十分に減衰できていることが解る。

【0032】上述した実施例の平衡不平衡変換器によれば、第1結合線路の第1端子、グラウンド間、第2結合線路の第2端子、グラウンド間、第1結合線路の第3端子、第4端子間、及び第2結合線路の第3端子、第4端子間にコンデンサを接続するため、低域通過フィルタ機能を有する平衡不平衡変換器を構成することができる。したがって、平衡不平衡変換器と低域通過フィルタとを別々の部品として形成する従来例と比較して、低域通過フィルタ機能を有する平衡不平衡変換器を簡単な構造で達成でき、その結果、低コスト化、小型化、加えて平衡不平衡変換器ー低域通過フィルタ間の伝送損失の低減を実現した低域通過フィルタ機能を有する平衡不平衡変換器を得ることができる。

【0033】また、第1～第12の誘電体層を積層してなる積層体を備えるとともに、第1及び第2結合線路を積層体の内部に設けた伝送線路で構成し、コンデンサを積層体の内部に誘電体層を挟んで互いに対向して設けたコンデンサ電極及びグラウンド電極で構成するため、平衡不平衡変換器の部品点数を低減することができる。したがって、平衡不平衡変換器のより低コスト化、小型化が可能である。

【0034】図6は、本発明の移動体通信装置に係る一実施例のブロック図である。移動体通信装置20は、アンテナ21、デュプレクサ22、送信回路23及び受信回路24で構成される。

【0035】デュプレクサ22は、送信回路23からの高周波信号をアンテナ21側へ送出するとともに、アンテナ21を介して受信した電波を受信回路24側へ振り分ける。

【0036】送信回路23は、高出力増幅器PA、周波数変換器CON1及び変調部MODで構成され、受信回路24は、低雑音増幅器LNA、周波数変換器CON2及び復調部DEMで構成される。

【0037】この際、送信回路23の周波数変換器CO

N1は、平衡不平衡変換器BAL11、BAL12、BAL3、ダブルバランスミキサMIX1、局部発振回路LOからなり、受信回路24の周波数変換器CON2は、平衡不平衡変換器BAL21、BAL22、BAL3、ダブルバランスミキサMIX2、局部発振回路LOからなる。

【0038】なお、平衡不平衡変換器BAL11、BAL22は、不平衡信号を180°の位相差で等分配して平衡信号とする分配器の役目を果し、平衡不平衡変換器BAL12、BAL21は、平衡信号を合成して不平衡信号とする合成器の役目を果す。

【0039】以上のような構成において、周波数変換器CON1、CON2を構成する平衡不平衡変換器BAL11、BAL21、BAL12、BAL22に、図1の低域通過フィルタ機能を有する平衡不平衡変換器10を用いるものである。

【0040】送信の際には、送信回路23におけるダブルバランスミキサMIX1の中間周波信号入力端子a1、b1に平衡不平衡変換器BAL12を介して中間周波信号が、局部発振信号入力端子c1、d1に平衡不平衡変換器BAL3を介して局部発振信号がそれぞれ供給され、出力端子e1、f1から中間周波信号と局部発振信号とにより変換された高周波信号が出力される。

【0041】一方、受信の際には、受信回路24におけるダブルバランスミキサMIX2の高周波信号入力端子a2、b2に平衡不平衡変換器BAL21を介して高周波信号が、局部発振信号入力端子c2、d2に平衡不平衡変換器BAL3を介して局部発振信号がそれぞれ供給され、出力端子e2、f2から高周波信号と局部発振信号とにより変換された中間周波信号が出力される。

【0042】なお、高周波信号及び中間周波信号における不要なスプリアス信号は平衡不平衡変換器BAL11、BAL12、BAL21、BAL22が有する低域通過フィルタ機能により除去される。

【0043】上述した実施例の周波数変換器によれば、低域通過フィルタ機能を有する平衡不平衡変換器を用いているため、部品点数を少なくすることができるとともに、伝送損失を低減でき、その結果、周波数変換器の低コスト化、小型化及び高性能化を実現することができる。

【0044】また、上述した実施例の移動体通信装置によれば、低コスト化、小型化及び高性能化が可能な周波数変換器を用いているため、移動体通信装置の低コスト化、小型化及び高性能化を実現することができる。

【0045】なお、上述の平衡不平衡変換器の実施例では、第1結合線路の第1端子、グランド間、第2結合線路の第2端子、グランド間、第1結合線路の第3端子、第4端子間、及び第2結合線路の第3端子、第4端子間の全てにコンデンサを接続した場合について説明したが、少なくとも1ヶ所にコンデンサを接続すれば低域通

過フィルタの機能を有することとなり同様の効果が得られる。

【0046】また、誘電体層が、酸化バリウム、酸化アルミニウム、シリカを主成分とするセラミックスの場合について説明したが、比誘電率(ϵ_r)が1以上であれば何れの材料でもよく、例えば酸化マグネシウム、シリカを主成分とするセラミックスあるいはフッ素系樹脂等でも同様の効果が得られる。

【0047】さらに、上述の移動体通信装置では、送信回路の周波数変換器と受信回路の周波数変換器とで平衡不平衡変換器及び局部発振回路を共通にした場合について説明したが、別々に設けられていてもよい。

【0048】

【発明の効果】請求項1の平衡不平衡変換器によれば、第1結合線路の第1端子、グランド間、第2結合線路の第2端子、グランド間、第1結合線路の第3端子、第4端子間、及び第2結合線路の第3端子、第4端子間の少なくとも1つにコンデンサを接続するため、平衡不平衡変換器と低域通過フィルタとを別々の部品として形成する従来例と比較して、低域通過フィルタ機能を有する平衡不平衡変換器を簡単な構造で達成でき、その結果、低コスト化、小型化、加えて平衡不平衡変換器—低域通過フィルタ間の伝送損失の低減を実現した低域通過フィルタ機能を有する平衡不平衡変換器を得ることができる。

【0049】請求項2の平衡不平衡変換器によれば、第1結合線路、第2結合線路及びコンデンサが、複数の誘電体層を積層してなる積層体で構成されるため、平衡不平衡変換器の部品点数を低減することができる。したがって、平衡不平衡変換器のより低コスト化、小型化が可能である。

【0050】請求項3の周波数変換器によれば、低域通過フィルタ機能を有する平衡不平衡変換器を用いているため、部品点数を少なくすることができるとともに、伝送損失の低減でき、その結果、周波数変換器の低コスト化、小型化及び高性能化を実現することができる。

【0051】請求項4の移動体通信装置によれば、低コスト化、小型化及び高性能化が可能な周波数変換器を用いているため、移動体通信装置の低コスト化、小型化及び高性能化を実現することができる。

【図面の簡単な説明】

【図1】本発明の平衡不平衡変換器に係る一実施例の等価回路図である。

【図2】図1の平衡不平衡変換器の具体例な構成を示す斜視図である。

【図3】図2の平衡不平衡変換器の積層体を構成する(a)第1の誘電体層～(h)第8の誘電体層の上面図である。

【図4】図2の平衡不平衡変換器の積層体を構成する(a)第9の誘電体層～(d)第12の誘電体層の上面図及び(e)第12の誘電体層の下面図である。

【図5】図1の平衡不平衡変換器の基本動作を示す
(a) 位相特性図、(b) 通過特性図である。

【図6】本発明の移動体通信装置に係る一実施例のブロック図である。

【図7】一般的な携帯電話機の回路構成を示すブロック図である。

【図8】従来の平衡不平衡変換器の等価回路図である。

【図9】の平衡不平衡変換器における1/2波長線路上の定在波の電圧・電流波形の模式図である。

【符号の説明】

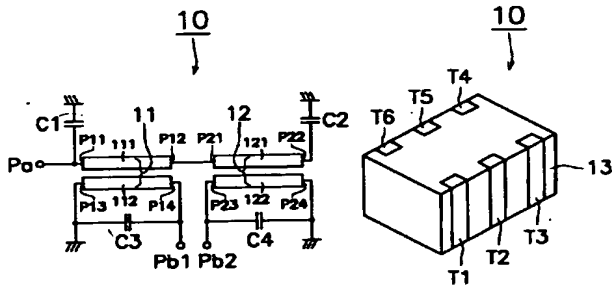
10 平衡不平衡変換器
11 第1結合線路
12 第2結合線路
111, 121 第1線路

112, 122 第2線路
13 積層体
13a~13l 誘電体層
20 移動体通信装置
21 アンテナ
23 送信回路
24 受信回路
C1~C4 コンデンサ
CON1, CON2 周波数変換器
10 DEM 復調部
MOD 変調部
P11~P14, P21~P24 第1~第4端子
Pa 平衡信号入出力端子
Pb1, Pb2 不平衡信号入出力端子

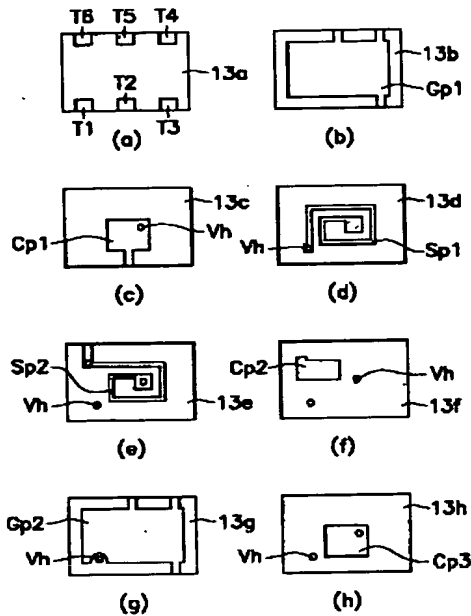
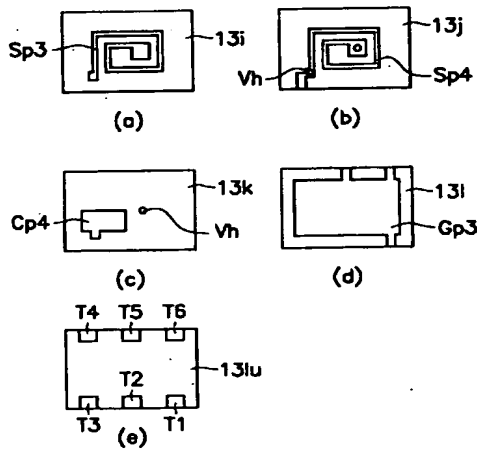
【図1】

【図2】

【図3】

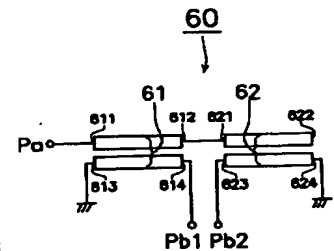
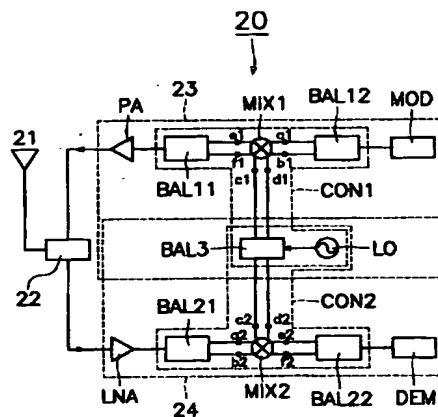


【図4】

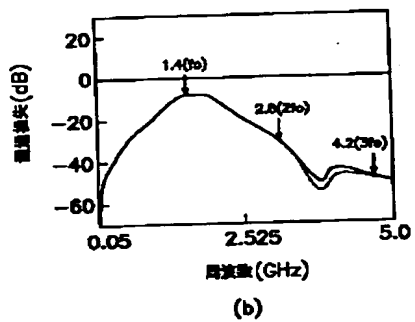
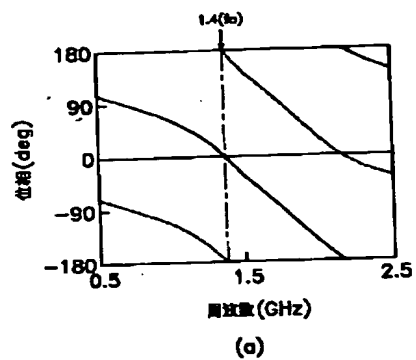


【図6】

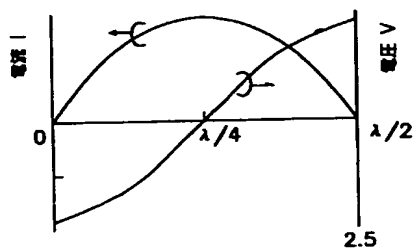
【図8】



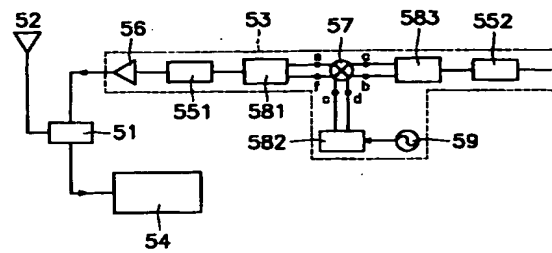
【図5】



【図9】



【図7】



フロントページの続き

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